

Research on Fault Detection and Diagnosis of Scrolling Chiller with ANN¹

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Abstract: At first the basic research about FDD is summarized, and a detection model based on ANN is initially set up. The paper presents experiments that simulate seven faults, including change flow rate of chilled water, cooling water and refrigerant, charge non-condense gas, shift temperature of cooling water and alter outside cold load. A set of characteristic parameters are defined in order to differentiate these faults and clarify the reasons. Finally, an FDD tool is programmed based on ANN with experimental results which form a training stylebook and test stylebook.

Keywords: Water Cooling Chiller of Screw Fault Diagnose Artificial Neural Network

1 INTRODUCTION

Artificial neural network based on the knowledge of neural network of human brain is to artificially form neural networks to implement some functions. It has powerful functions to store and process information. It is widely used in the fields of control and mode identifying. This paper is for the purpose of using artificial neural network to diagnose the faults normally happening in the HVAC systems and does some researches on the fault diagnosis of screw chiller.

2 DETECTION MECHANISM

The refrigerating cycle of screw chiller is consisted of four thermodynamic cycles which are compression, heat discharging, throttling and heat absorbing. the change of one or some of the parameters will lead to the changes of many other parameters^[2]

The 8 faults simulated in this paper are that the cooling water flow decreases or increases, chilled water flow decreases or increases, non-condensable gas is added in, cooling load decreases, the inlet water temperature of the condenser is over high and

the refrigerant flow decreases.

3 EXPERIMENT PRECEPETS AND DEVICES

3.1 Experiment Disposal Precept

According to the theoretic analysis, interior parameters are chosen as the feature parameters^[3].

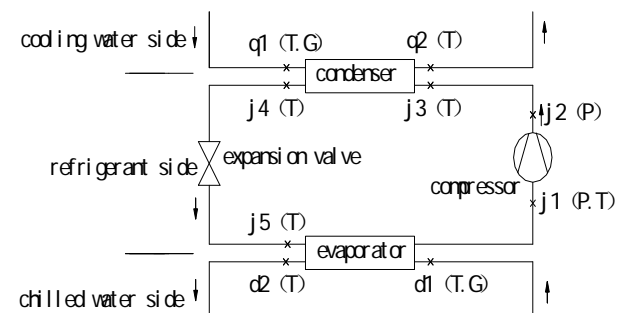


Fig.1 The measuring position and parameters

In the figure: q—cooling water side; d—chilled water side; j—refrigerant; P—pressure side; T—point for temperature measuring; G—point for flux measuring

In order to understand the actual operating situation of the units, several necessary physical points are set for measuring.

3.2 Experiment Devices

There are a single-screw chiller and a chilled water pump, a cooling water pump, two electrostatic precipitators, a water separator and a water collector in the refrigeration machinery room.

The temperature conditions of chiller rating running situation: chilled water inlet temperature is 12°C, extracted temperature is 7°C; cooling water inlet temperature is 32°C.

The performance parameters of two pumps are:
 Lift: 32m water column; Rated flow: 100 m³/h;
 Power supply: 3 Φ-380V-50Hz; Input power: 15kW.

¹ Issued by Chongqing University primary teachers

4 RESULTS ANALYSIS

4.1 The cooling water flux decreases.

As figure 2 shown: considering the errors, the evaporating temperature and the compressor suction temperature do not change as the cooling water flux changes; the condensing temperature, the compressor discharge temperature and the sub-cooling degree of refrigerant increase as the cooling water flux decreases. The principle for predicting this fault is concluded as following:

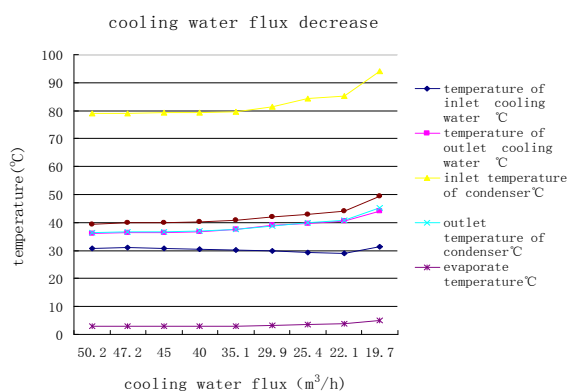


Fig.2 The curve of the system parameter with decreasing flux of cooling water

$|T_1-4.2| \leq 0.3$ Evaporating temperature keeps constancy

$T_2-42.0 > 0.3$ Condensing temperature increases

$|T_{J1}-9.0| \leq 0.3$ Compressor suction temperature keeps constancy

$T_{J2}-78 > 0.3$ Compressor discharge temperature increases

$\Delta T_J - 5.0 > 0.3$ Sub-cooling Degree of refrigerant increases

Attention: all of the units in the 3.1 to 3.9 are °C

4.2 The cooling water flux increases

The experiment results are shown as figure 3. It can be considered as the evaporating temperature does not change when the cooling water flux changes.

The principle for predicting this fault is concluded as following:

$|T_1-4.2| \leq 0.3$ Evaporating temperature keeps constancy

$T_2-42.0 < -0.3$ Condensing temperature decreases

$|T_{J1}-9.0| \leq 0.3$ compressor suction temperature keep constancy

$T_{J2}-78 < -0.3$ Compressor discharge temperature decreases

$\Delta T_J - 5.0 < -0.3$ Sub-cooling degree of refrigerant decreases.

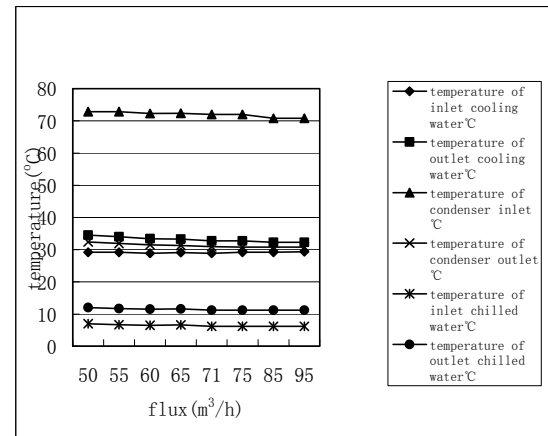


Fig 3 The curve of the system parameter with increasing flux of cooling water

4.3 Chilled water flux increases

As we can see from figure 4, when the chilled water flux increases, the power of compressor increases, the parameters of cooling water almost keep constancy, evaporating temperature increases, condensing temperature almost keeps constancy, compressor suction temperature increases.

The principles for predicting this fault are concluded as following:

$T_1-4.2 > 0.3$ evaporating temperature increases

$|T_2-42.0| \leq 0.3$ condensing temperature keep constancy

$T_{J1}-9.0 > 0.3$ compressor suction temperature increases

$|T_{J2}-78| \leq 0.3$ compressor discharge temperature keeps constancy

$\Delta T_J - 5.0 > 0.3$ sub-cooling degree of refrigerant increases

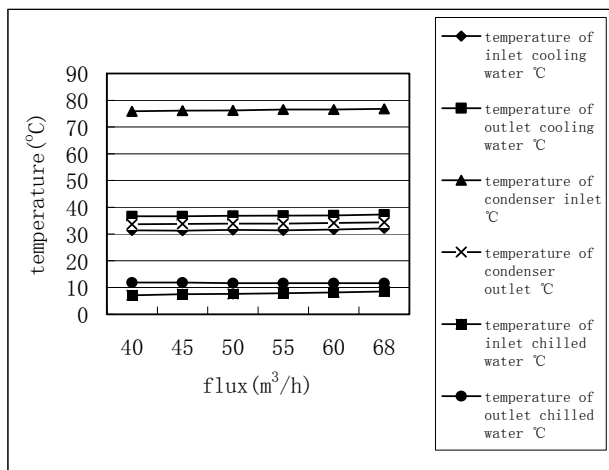


Fig 4 The curve of the system parameter with increasing flux of chilled water

4.4 chilled water flux decreases

According to the changes of perimeters the principles for predicting this fault are shown as following:

- T1-4.2 < -0.3 evaporating temperature decreases
- |T2-42.0| \leq 0.3 condensing temperature keeps constancy
- TJ1-9.0 < -0.3 compressor suction temperature decreases
- |TJ2-78| \leq 0.3 compressor discharge temperature keeps constancy
- Δ TJ-5.0 < -0.3 sub-cooling degree of refrigerant decreases

4.5 Adding in non-condensable gas

The principle for predicting this fault is shown as follows:

- T1-4.2 > 0.3 evaporating temperature increases
- T2-42.0 > 0.3 condensing temperature increases
- TJ1-9.0 > 0.3 compressor suction temperature increases
- TJ2-78 > 0.3 compressor discharge temperature increases
- Δ TJ-5.0 > 0.3 sub-cooling degree of refrigerant increases

4.6 Exterior cooling load decreases

According to the changes of perimeters, the principles for predicting this fault are shown as following:

- T1-4.2 < -0.3 evaporating temperature decreases
- T2-42.0 < -0.3 condensing temperature decreases

TJ1-9.0 < -0.3 compressor suction temperature decreases

|TJ2-78| \leq 0.3 compressor discharge temperature keeps constancy

| Δ TJ-5.0| \leq 0.3 sub-cooling degree of refrigerant keeps constancy.

4.7 The inlet water temperature is over high

According to the changes the principles for predicting this fault are shown as following:

- T1-4.2 > 0.3 evaporating temperature increases
- T2-42.0 > 0.3 condensing temperature increases
- TJ1-9.0 < -0.3 compressor suction temperature decreases
- TJ2-78 > 0.3 compressor discharge temperature increases
- Δ TJ-5.0 > 0.3 sub-cooling degree of refrigerant increases

4.8 Refrigerant flux decreases

The principles for predicting this fault are shown as following:

- T1-4.2 < -0.3 evaporating temperature decreases
- T2-42.0 < -0.3 condensing temperature decreases
- TJ1-9.0 > 0.3 compressor suction temperature increases
- TJ2-78 > 0.3 compressor discharge temperature increases
- Δ TJ-5.0 > 0.3 sub-cooling degree of refrigerant increases

5 THE APPLICATION OF ARTIFICIAL OF ARTIFICIAL NEURAL NETWORK ON THE FAULT DIAGNOSIS OF SCRWE CHILLER

5.1 Artificial neural network has integrated many advantages of the biology neural network and has some inherent characteristics: Able to work on two or more tasks at one time; Highly nonlinear overall function; Able to memorize and correct error and associate thoughts; Be able to adapt and learn by self.

5.2 The model of artificial neural network on the fault diagnosis of screw chiller, see figure 5.

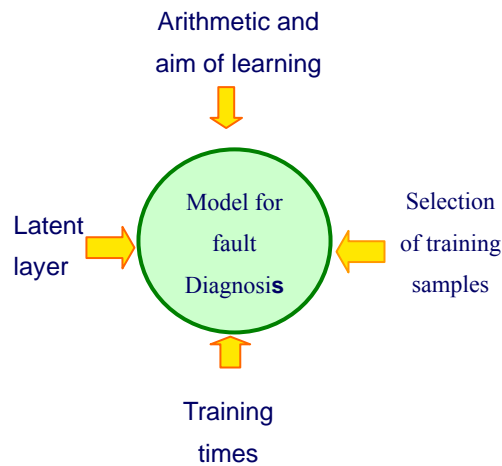


Fig. 5 Establishment of faults diagnosis model

5.3 Prediction example

According to the network trained previously, the program of faults diagnosis can be obtained. Inputting the data collected from the chiller when it is operating, see table 1 and table 2.

Tab.1 experimental validation

输入	Fault Type
13.1, 8.2, 34.1, 39.2, 16.44, 5.38, 78.8, 36.6, 8.8, 78.1, 4.7	normal
12.7, 7.7, 30.8, 36.2, 5.3, 14.6, 75.7, 33.9, 8.5, 4.6, 4.4	normal
12.4, 7.5, 33.4, 38.3, 15.66, 5.66, 78.1, 36.0, 8.4, 77.6, 4.4	normal
10.8, 6.3, 33.6, 38.4, 16.15, 5.10, 78.5, 36.0, 6.4, 77.9, 4.3	non-condensable gas
12.3, 7.6, 33.9, 38.8, 16.35, 5.30, 78.7, 36.3, 8.3, 78.1, 4.5	non-condensable gas
12.7, 7.9, 32.8, 37.6, 17.71, 5.34, 81.7, 35.3, 7.6, 79.9, 4.7	Cooling water flux over small
12.9, 8.3, 32.7, 37.6, 20.55, 5.53, 95.3, 37.0, 10.3, 93.5, 4.0	Cooling water flux over small

Tab.2 comparison between output of network and experiment results

Output of network	Experiment results
0.0081, 0.0201, 0.0640, 0.2256, 0.0170, 0.0358, 0.0492, 0.0447 , 0.0492, -0.0447	0 0 0 0 0 0 0

0.0041, 0.1036, 0.0036, 0.0645, 0.1314, 0.0592, 0.0645, 0.0394, 0.0645, 0.0394 0.0197, 0.1527, 0.0497, 0.1946, 0.0581, 0.1850, 0.0661, 0.0088, 0.0661, 0.0088 0.0107, 0.9909, 0.0031, 0.0248, 0.0348, 0.0124, 0.0301, 0.0265, 0.0301, 0.0265 0.0150, 0.9966, 0.0372 , 0.0481, 0.0301, 0.0939, 0.0108, 0.0097, 0.0108, 0.0097 0.0485, 0.1916, 0.9179, 0.0159, 0.0629, 0.0231, 0.0721, 0.1625, 0.0721, 0.1625 0.0270, 0.0243, 0.9966, 0.0104, 0.0121, 0.0067, 0.1134, 0.0221, 0.1134, 0.0221	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0
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If the output is bigger than 0.9, the type of fault can be predicted. The performance of network needs to be tested by large amount of samples. In this paper, the network has been tested by the data obtained from 100 faults experiments and it is proved that the performance of the network is good.

When it is operating, the parameters of chiller are listed as follow:

According to the table, the output of the network is close to the experiments. The conditions for predicting the fault have been met.

6 CONCLUSIONS

This paper specifically analyzed the factors which can influence the performance of chiller, at the same time, attained how various faults influence the characteristic parameters and the performance of chiller via experiment method.

This paper researched the faults diagnosis of screw chiller through the method of artificial neural works, and exactly predicts the happening of chiller faults.

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